

Institute of Anatomy, University of Zürich
(Dir. Prof. Dr. G. Töndury)

The Development of the Intramural Nerve Plexus of the Gastro-Intestinal Tract

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Hans-Peter Keller

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The Development of the Intramural Nerve Plexus of the Gastro-Intestinal Tract

Hanspeter Keller

Institute of Anatomy, University of Zürich (Dir. Prof. Dr. G. Töndury)

Summary. The chicken intestinal tract from the 6th day of breeding until the 20th day after hatching was examined histochemically for acetylcholinesterase activity.

The enzyme was detected first in the perikarya and subsequently also in the ganglion-cells processes.

The appearance of the acetylcholinesterase reaction deposit was observed first in the stomach and duodenum and later in the rectum.

The histogenetic development of the intramural plexus in the small gut proceeds caudad, but in the colon in the opposite way, i.e., craniad.

In the duodenum and colon the nervous development is complete in chicken embryos of 11–12 days and in the rest of the small intestine in embryos of 13–14 days of breeding. In the human embryo of 60 mm CRL the development of the intramural plexus is already completed.

Key words: Vegetative ganglia – Development – Gut – Chick

I. Introduction

A study of the literature on the intramural plexus of the gastro-intestinal tract (Auerbach and Meissner) showed that the information regarding the prenatal development of the ganglia is still incomplete.

Hlozankova and Hampl (1972) performed a quantitative analysis of the growth dynamics and Gabella (1949) studied the postnatal development of the intramural innervation in the rat intestinal tract. Bodian (1949), Hüther (1954) and Rohner (1961) discussed the development of the intramural plexus in relation to Hirschsprung's disease.

Since the reports of the first appearance of the intramural plexus and its further distribution lack clarity and show some contradictions, we made an attempt to study this problem in the chicken intestine at different stages of development.

II. Material and Methods

From 63 chicken embryos (6th to 20th breeding day) using a stereomicroscope, and from 15 chickens of the same White Leghorn species aged between 12 h and 20 days, the intestinal tract was removed in toto. The isolated preparation was fixed for 6 h in a buffered 4% formaldehyde solution, washed in distilled water and incubated for specific cholinesterase according to the Gomori method (1952). The substrate used was acetyl-thiocholine (Fluka), with the other ingredients as indicated in the method.

Since this solution is supposed to keep indefinitely stable at pH 6.0, we left the tissue incubate for 4 h at room temperature. Some of the incubated whole preparations were, without counter-staining the nuclei, dehydrated and mounted in a synthetic neutral resin (Caedax). In order to determine the location of the cholinesterase-active structures in the intestinal wall, other preparations were cut in pieces, embedded in paraffin and cut into sections, which were counter-stained with kernechtrot for visualization of the nuclei. In addition, a human embryo of 60 mm CRL – about 12 weeks of gestation – was used for the same investigation.

III. Findings

The results are summarized in Table 1. The very first evidence of cholinesterase activity was found in the perikarya of the ganglion cells, appearing as a spotted pattern in the light microscope (Fig. 1a). One day later, the reaction became

Table 1: Summary of results

Age (days)	Stomach and duodenum	Rest of small intestine	Large intestine and caecal processes
6	—	—	—
7	First, weak reaction of ganglia cells in the top of duodenum; first appearance of a reticular plexus in stomach, especially large curvature	—	—
8	Numerous ganglion cells in the stomach with clearly visible reticulum; in duodenum perikaryal reaction, grouping of ganglion cells in a sort of spotted pattern	Ganglia cells in most oral part	First ganglia cell complexes in rectum; rest of colon and caecal processes show no reaction
9	Well-developed reticulum in duodenum with numerous connections between ganglia cells	Increase of perikaryal reaction; reticulum in most oral parts	Circular reticulum in whole colon; decrease of density from oral to aboral
10	Further increase of density of reticulum in duodenum	Ganglia cells in most aboral part; further spreading of reticulum in distal distribution	Well-developed reticulum in all parts, incl. caecal processes
11	Maximum development of plexus in duodenum is attained	Further spreading of plexus in distal distribution	Maximum development of plexus in whole colon is attained
12	See day 11	See day 11	See day 11
13–14		Well-developed reticulum in all parts of small intestine	

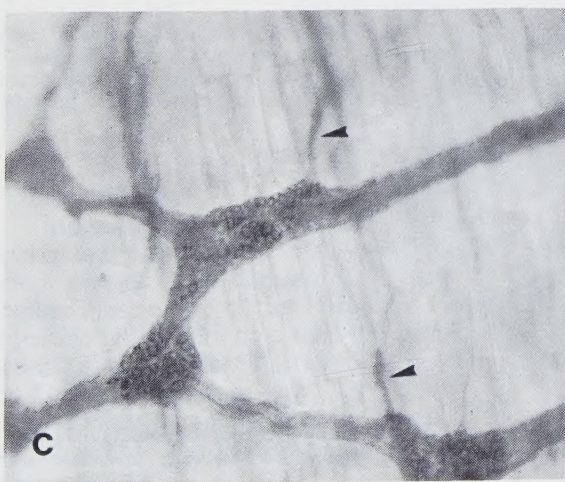
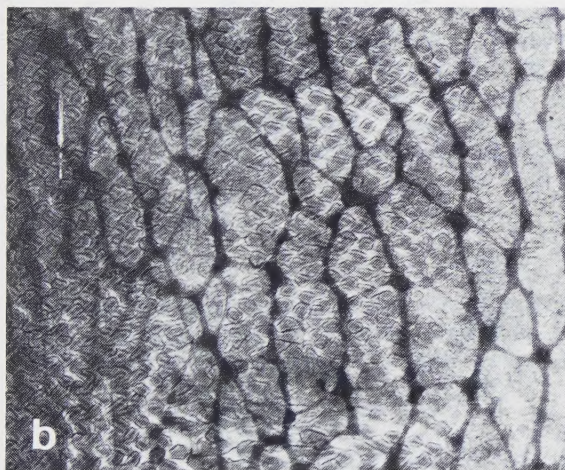
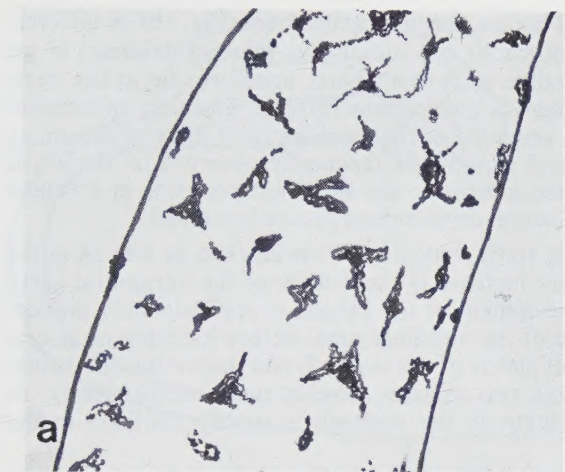


Fig. 1a-c. Cholinesterase activity in total preparation of intestinal tract. **a.** Duodenum of a chicken embryo of 8 days. Spotted pattern. $\times 60$. **b.** Small intestine, cut open and spread out. Chicken 1 day old. Reticular plexus. $\times 18$. **c.** Small intestine, cut open, mucosa removed. Chicken 2 days old. $\times 60$. The perikarya of the ganglion cells of the myenteric plexus are clearly visible. Single connections with the submucous plexus are recognizable (arrows). The ground striation originates in the muscle

positive in the processes of the cell bodies, forming a reticulum (Fig. 1b). A differentiation between the myenteric (Auerbach) and submucous plexus (Meissner) in the total preparation is almost impossible since both parts appear to lie in the same plane and they are linked by numerous connections (Fig. 2). The first appearance of the intramural nerve system is observed in the stomach (6–7 days of breeding), followed later by the duodenum and rectum. As repeatedly observed on the whole preparation, the development of the ganglia in the small gut proceeds in a caudal direction, whereas in the colon the neural development proceeds craniad.

From the 15th day of breeding to the hatching of the chicken as well as in the postnatal period, there is no further increase in the density of the intramural nerve plexus. The further numerical development of the ganglia is approximately proportional to the surface area increase of the intestinal tube. Before hatching no neural connections between the intramural plexus of the stomach and that of the duodenum could be observed. Evidently, these two systems develop quite independently. In continuation the growth of the plexus in the stomach is strictly confined to the two curvatures.

The findings in the whole preparation were confirmed by light microscopic examination of the embedded tissue sections. The elements of the intramural plexus were shown to lie between the muscular layers and in the submucosa. Numerous connections could be seen between the submucous plexus and the myenteric plexus (Fig. 2).

The human embryo showed that at the age of 12 weeks the development of the plexus is complete in the large as well in the small intestine.

IV. Discussion

The full functional activity of a part of the intestine is dependent on the completed development of the corresponding intramural ganglion system. We can therefore assume that the duodenum and the colon in the chicken embryo begin to function



Fig. 2. Cross section through the colon of a chick of 11 days. Cholinesterase reaction in total preparation. Kernechtrot-colouring of the section. $\times 60$. Connections between myenteric and submucous plexus are clearly recognizable

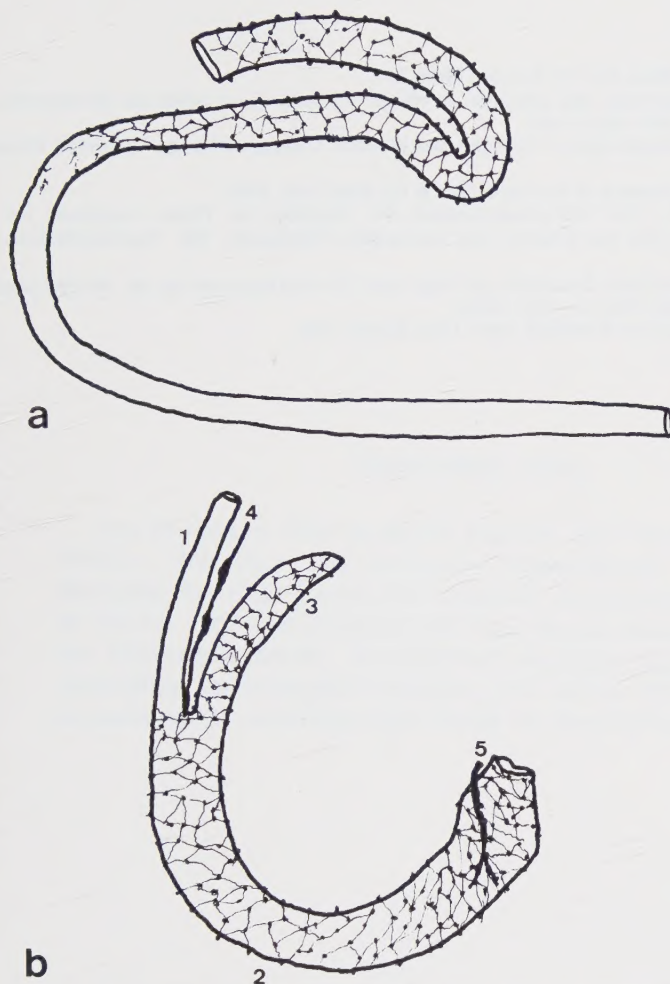


Fig. 3a and b. Total preparation of intestinal tract after cholinesterase reaction. Chicken embryo, 10 days old. $\times 12$. **a.** Duodenal loop with beginning of jejunum. **b.** Terminal small intestine (1), colon (2), caecal processes (3), nerve (4), artery (5). Reticular nerve plexus is visible in duodenum and large intestine, but missing in the rest of the small intestine

at the 11th to 12th day. The remaining parts of the intestine start to function on the 13th to 14th day.

Moreover, our investigations show that the histogenetic differentiation of the intramural plexus in the small intestine progresses caudad and in the large intestine from craniad. The first ganglia appear in the stomach and the duodenum 24 h before those of the rectum. However, the formation of the large plexus of the small intestine takes more time than the establishment of the plexus in the colon which is considerably shorter. Therefore both parts, the small intestine and the colon, start to function at the same time.

As in the human embryo the plexus of the whole intestine is complete at the age of 12 weeks. The first stages of nerve plexus development must be sought at an earlier period.

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Curriculum vitae

Am 20. August 1947 in Zürich geboren. Hier besuchte ich auch die Primar-, Sekundar- und kantonale Oberrealschule, die ich mit der Maturität Typ C im Herbst 1967 abschloß. Beginn des Medizinstudiums im Herbst 1967 und Abschluß mit dem Staatsexamen im Mai 1974 an der Universität Zürich. Anschließend einjährige allgemeinchirurgische Ausbildung am Kreisspital Samedan, seit Januar 1976 bin ich als Assistenzarzt an der neurologischen Klinik des Inselspitals in Bern tätig.

